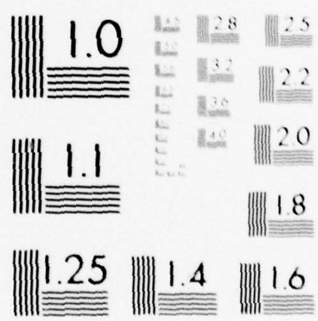
AD-A077 846 BURROUGHS CORP PAOLI PA FEDERAL AND SPECIAL SYSTEMS GROUP F/G 9/2
MODULAR SYSTEM CONTROL DEVELOPMENT MODEL (MSCDM).(U)
NOV 79 DCA100-76-C-0083
UNCLASSIFIED 64335 SBIE-AD-E100 306 NL

1 OF 1
AD
A077846

END
DATE
FILMED
1-80
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD-E100 306

LEVEL III

64335

November 1979

DDC RECEIVED NOV 30 1979 E

AD A077846

DDC FILE COPY

FINAL REPORT

FOR THE

MODULAR SYSTEM CONTROL DEVELOPMENT MODEL (MSCDM)

for

THE DEFENSE COMMUNICATIONS AGENCY
WASHINGTON, D.C. 20305

Burroughs Corporation
Federal and Special Systems Group
Paoli, Pa. 19301

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 14 64335	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER rept.
4. TITLE (and Subtitle) 6 ~~Final Report for the~~ Modular System Control Development Model (MSCDM).		5. TYPE OF REPORT & PERIOD COVERED 9 FINAL Sep 76 – Nov 79.
A077845		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s) 15 DCA100-76-C-0083
9. PERFORMING ORGANIZATION NAME AND ADDRESS Burroughs Corporation Federal and Special Systems Group Paoli, PA 19301		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 33126 T&CCP 3012 Task 15203
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Communications Agency Defense Communications Engineering Center 1860 Wiehle Ave., Reston, VA 22090		12. REPORT DATE 11 November 1979 13. NUMBER OF PAGES 50
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 53		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

18 SBIE 19 AD-E100 306

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ring Network	Channel Reassignment
Loop Network	SENET
System Control Modules	Interoperability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes each system control module provided in the delivered MSCDM. The tech control functions of trending and fault isolation as well as switch control operations are described. Possible experimental programs utilizing the MSCDM are presented. These programs include studies of the channel reassignment function, interoperability, the SENET Concept, distributed operating systems, distributed data concepts and security in a distributed system.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE 79 11 26 064 UNCLASSIFIED

070040 Jm

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

64335

November 1979

Burroughs

FINAL REPORT

FOR THE

MODULAR SYSTEM CONTROL DEVELOPMENT MODEL (MSCDM)

for

THE DEFENSE COMMUNICATIONS AGENCY
WASHINGTON, D.C. 20305

Burroughs Corporation

Federal and Special Systems Group

Paoli, Pa. 19301

Contents

List of Figures

<u>List of Tables</u>

1. SYSTEM CONTROL FEASIBILITY DEVELOPMENT MODEL IMPLEMENTATION

1.1 System Control Modules

The Modular System Control Development Model (MSCDM) consists of nine functional modules: Station-to-Station Communications Interface (SSCI), Voice Service Quality Control (VSQC), Digital Service Quality Control (DSQC), Data Base Management Service (DBMS), Baseband Signal Analysis and Wide Band Signal Analysis (BWBSA), Operator Control and Report Interface (OCRI), Fault Isolation and Control Coordination (FIAC), Switch Data Collection and Analysis (SDCA), and Simulated Input Generator (SIG). Each of these modules is implemented using microcomputer hardware and software, and module intercommunication is performed via a Burroughs Loop or Ring Architecture.

1.1.1 SSCI

The Station-to-Station Communication Interface (SSCI) serves as a gateway node interface to loop 4 of the ESM. The loop 4 - loop 5 interface implemented is 9600 baud asynchronous. The SSCI is used to simulate communication between different system control sites. The SSCI performs code conversion, intransit queueing and packet routing.

1.1.2 VSQC

The Voice Service Quality Control (VSQC) module performs performance assessment of voice channels for the purpose of detecting degrading performance and assisting in fault isolation. The MSCDM is capable of monitoring at least 1000 channels. By convention channels numbered 1-500 are monitored by the VSQC. There are six parameters to be checked per channel:

1. Peak Power (PK)
2. Average Power (AV)
3. Frequency Offset (FO)
4. Phase Jitter (PJ)
5. C-Message Noise (CN)
6. 3 KHz Flat Noise (FN)

The parameters are generated by the Simulated Input Generator (SIG) microcomputer. Thresholding is done on the parameters by comparison with the Red High (RH), Red Low (RL), Amber High (AH), and Amber Low (AL) values in order to determine whether the channel parameter is in the Red, Amber or Green region as shown in Figure 1-1.

The parameter thresholds for the VSQC are given in Table 1-1.

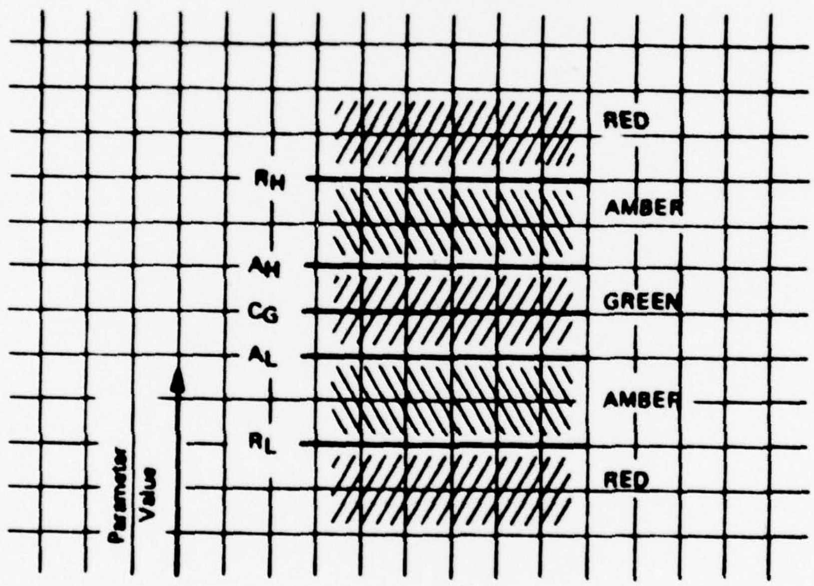


Figure 1-1. Parameter Thresholds

Table 1-1. VSQC Parameter Thresholds

Parameter	RH	RL	AG	AL	Units
PK	10	0	8	2	dBm0
AV	10	0	8	2	dBm0
FO	20	-100	0	-80	Hz
PJ	10	-90	-10	-70	deg
CN	0	-80	-10	-60	dBm0
FN	20	-100	0	-80	dBm0

The VSQC also performs trending on the parameter values. Thrending begins when the parameter is within a delta value of the Threshold. The critical trending values for the VSQC parameter thresholds are given in Table 1-2.

Table 1-2. VSQC Critical Trending Values

Parameter	Delta	RHT	RLT	AHT	ALT
PK	0.5	9.5	0.5	7.5	2.5
AV	0.5	9.5	0.5	7.5	2.5
FO	3	17	-97	-3	-77
PJ	2	8	-88	-8	-68
CN	1	-1	-79	-19	-59
FN	2	18	-98	-2	-78

The threshold and trending values may be modified by modifying the program DATA statement and recompiling the VSQC nodal software.

Event Reports are sent to the FIAC when a parameter value is Amber or red and the Event Reporting condition parameter is turned ON (via Module Update Mode 3 of the User Language). Event Reports consists of an 8-byte trunk name, 4-byte channel number, one-byte condition, one-byte parameter number that caused the Red or Amber condition, 3-byte monitor point number, and the node designator to which reports should be sent.

The VSQC interprets commands from the DBMS generated by Mode 3 of the User Language. The commands include Event Reporting ON or OFF; if ON the node designator to which the Event Reports are to be sent, i.e., the terminal used for display, is given. The VSQC also interprets the command, received as a packet from the loop, to measure a specific channel which is sent to the SIG; the resulting measurement value is sent to the OCRI terminal requesting the measurement (via Mode 3 of the User Language).

1.1.3 DSQC

The Digital Service Quality Control (DSQC) module assesses the performance of digital data channels for the purpose of detecting degrading performance of these channels with respect to increasing error rates, and to assist in fault isolation. Channels numbered 501-1000 are arbitrarily monitored by the DSQC. There are three parameters to be checked per channel:

1. Pseudo Error Rate (PE)
2. Bit Error Rate (BIE)
3. Block Error Rate (BLE)

The parameters are generated by the SIG. The parameter thresholds for the DSQC are given in Table 1-3.

Table 1-3. DSQC Parameter Thresholds

Parameter	RH	RL	AH	AL	Units
PE	10	-10	5	-5	%
BIE	10	-10	5	-5	%
BLE	10	-10	5	-5	%

Trending occurs when the parameter value is within one of the red threshold, or two of the AMBER thresholds. Event reports are sent to FIAC using the same format as described for VSQC. The DSQC interprets the same commands generated by the DBMS as the VSQC.

1.1.4 DBMS-PDU

The Data Base Management Service (DBMS) performs the data base maintenance functions. It maintains the display files for the human interface User Language, system configuration files, equipment status files, and object files for the various modules. The User Language runs on the DBMS and is used to control the system. Mini disks are used to store the various files. The DBMS may also be used as a Program Development Unit (PDU) with a local CRT terminal when not being used for the MSCDM application. The PDU develops and maintains software for the MSCDM. The PDU runs the RT-11 Operating System and it may be used as a general purpose processor.

1.1.5 OCRI

The Operator Control and Report Interface (OCRI) performs the functions of interfacing to the site operator. The User Language interface, when the OCRI terminal is ATTACHED to the DMBS node, allows the operator to control the site, request status information concerning site and equipment performance and prepare site reports which are forwarded to other sites such as a simulated ACOC. Operator to operator messages are also supported by the User Language. The OCRI terminal can be used to print event reports, fault reports, and alarms for the simulated equipment generated by the FIAC and SDCA modules, and error messages concerning the FDM itself generated by the nodal modules (e.g., Loop-Back in effect, queue overflow).

1.1.6 BWBSA

The Base Band Signal Analysis and Wide Band Signal Analysis (BWBSA) module performs performance assessment on link equipment. Three links are monitored. There are seven parameters to be checked per link for the baseband:

	Units
1. Transmitter Percent Modulation (BTPM)	%
2. Transmitter Frequency Deviation (BTFD)	Hz
3. Relative Transmitter Power (BRTP)	dBm0
4. Receiver AGC Voltage (BRAV)	DC Volts
5. Receiver IF Output (BRIO)	DC Volts
6. Multiplex Baseband Levels (BMBL)	dBm0
7. Multiplex Pilot Levels (BMPL)	dBm0

There are six parameters for the wideband:

		Units
8.	Transmitter Percent Modulation (WTPM)	%
9.	Transmitter Frequency Deviation (WTFD)	Hz
10.	Relative Transmitter Power (WRTP)	dBm0
11.	Receiver AGC Voltage (WRAV)	DC Volts
12.	Receiver IF Output (WRIO)	DC Volts
13.	Multiplexor Pseudo Error Rate (WMPE)	%

The parameter thresholds for the three links are given in Table 1-4.

Table 1-4 BWBSA Parameter Thresholds

Parameter	Value Limits	RH			RL			AH			AL		
		1	2	3	1	2	3	1	2	3	1	2	3
BTPM	-100,100	1	2	3	-1	-2	-3	.5	1	1.5	-.5	-1	-1.5
BTFD	$-\infty, \infty$	10	20	30	-10	-20	-30	5	10	15	-5	-10	-15
BRTP	0, 3600	3420	3400	3440	180	190	170	3240	3250	3240	360	350	370
BRAV	-10, 10	9	8.5	9.5	-9	-8.5	-9.5	8	7.5	8.5	-8	-7.5	-8
BRIO	0, -100	-10	-9	-8	-90	-88	-92	-20	-18	-16	-80	-82	-82
BMBL	0, +4	4	3.9	3.8	.2	.3	.4	3	3.1	3.2	.8	.9	.7
BMPL	10, -60	3	4	5	-53	-54	-52	-4	-5	-5	-46	-45	-45
WTPM	-100, 100	1	2	3	-1	-2	-3	.5	1	1.5	-.5	-1	-1.5
WTFD	$-\infty, \infty$	10	20	30	-10	-20	-30	5	10	15	-5	-10	-15
WRTP	0, 3600	3420	3400	3440	180	190	170	3240	3250	3240	360	350	370
WRAV	-10, 10	9	8.5	9.5	-9	-8.5	-9.5	8	7.5	8.5	-8	-7.5	-8
WRIO	0, -100	-10	-9	-8	-90	-88	-92	-20	-18	-16	-80	-82	-82
WMPE	-100, 100	10	9	9	-10	-9	-9	5	4.5	4	-5	-4.5	-4

The parameters are generated by the SIG. In addition, alarms are generated associated with the three links for transmitters, receivers, and multiplexors. Alarms and Red and Amber threshold values are sent to the FIAC as Event Reports. Event Reports consist of one-byte link number, 2-byte baseband number, 2-byte wideband number, one-byte supergroup, one-byte group, one-byte condition, 2-byte parameter number that caused the Red or Amber condition, a 3-byte monitor point number, and the node designator to which reports should be sent.

The BWBSA interprets commands from the DBMS similar to the VSQC and DSQC except that measurements are performed for 3 links rather than channels.

1.1.7 FIAC

The Fault Isolation and Control Coordination (FIAC) module interprets Event Reports and Alarms from the VSQC, DSQC, and BWBSA modules for the purpose of isolating the equipment causing the detection of a fault condition. Amber and Red Event Reports are received by the FIAC and retransmitted to the destination Node Designator for OCRI reporting and to the DBMS in order to update the Equipment Status File. The OCRI operator can display and modify the Equipment Status File via Mode 6 of the User Language. Red Event Reports are reported only once when the equipment first fails although subsequent measurements will also result in the Red Region.

The FIAC analyzes the Red Event Reports for fault indications and initiates isolation procedures to resolve to the equipment level the location of the fault. The FIAC checks the connectivity through the network. For the delivered MSCDM, the assumed connectivity between the VSQC, DSQC and BWBSA is given in Table 1-5.

Table 1-5. FDM Assumed Connectivity

Connectivity Group	Monitor Points
Area 1	1-333
Area 2	334-666
Area 3	667-1000

The FIAC collects Red Event Reports and assigns them to the various connectivity groups. When a connectivity group has a Red Event Report from VSQC, DSQC and BWBSA, the monitor points are compared to determine the equipment causing the fault. The lowest monitor point indicates the equipment causing the fault. Fault Reports are then sent to both the local OCRI terminal and a remote site OCRI. The Fault Report contains the monitor points, link and channel numbers for the connectivity group. The FIAC software contains variables used to specify the Node Designators for the Local and Remote destinations for Fault Reports. The default nodes are the OCRI terminal for Local Fault Reports and the CRT terminal in loop 4 for Remote Fault Reports.

In the MSCDM, software resides on the SDCA node to simulate the behavior of a remote FIAC. Area 1 is used to represent the area associated with the MSCDM FIAC. Area 2 is used to represent the area associated with the remote FIAC (as simulated by SDCA). Area 3 is used to simulate other areas for which faults cannot be isolated by the FIAC. The SDCA sends occasional random Event Reports to FIAC with Monitor Points in Area 1. FIAC sends Event Reports to SDCA for those Event Reports received from VSQC, DSQC, and BWBSA with Monitor Points in Area 2. When Red Event Reports are collected for the VSQC, DSQC, and BWBSA, faults can be isolated and reported for Areas 1 and 2 but cannot be isolated for Area 3. The faults that cannot be isolated are reported to local and remote OCRI's via a Fault Report.

1.1.8 SDCA

The Switch Data Collection and Analysis (SDCA) module receives switch traffic data generated by AUTODIN or AUTOVON switches, and performs loading assessments on this data to detect switch equipment saturation conditions. Traffic flow control computations and actions are performed. Simulated data to represent two switches is generated by the PDP 11/40 in loop 2. A switch condition report is sent by the PDP 11/40 to the SDCA approximately every 2.5 seconds. The switch condition report consists of 16 fields as given in Table 1-6.

Table 1-6. SDCA Switch Condition Report

Field	Description	Critical AUTODIN	Values AUTOVON
1	Switch #	1	2
2	# of Transactions	512	256
3	# of Blocked Transactions	25	10
4	Transaction Queue Depth	25	10
5	# of Prescripted Transactions	10	25
6	Trunk Group Occupancy	50	40
7	Trunk Group Overflow	50	40
8	Message Delay (sec.)	10	5
9	Maximum Message Age (sec.)	10	5
10	Number of Overflow Messages	10	10
11	# of Senders	128	64
12	# of Markers	128	64
13	# of Receivers	128	64
14	# of Pooled Crypto Units	128	64
15	Service Time for Dial Tone (sec.)	10	5
16	Service Time for Crypto Unit (sec.)	10	5

Whenever a critical value of Table 1-6 is exceeded and the Event Reporting Condition Parameter is ON, the switch is considered to be in a saturated condition and Red Event Reports are sent to the DBMS Status File and the destination Node Designator for OCRI reporting.

The SDCA interprets commands from the DBMS similar to the VSQC, DSQC and BWBSA except that measurements are performed for 2 switches rather than channels or links.

1.1.9 SIG

The Simulated Input Generator (SIG) is a microprocessor that generates simulated inputs to the VSQC, DSQC, and BWBSA modules.

It acts as both a communications sensor and a scanner. It is used to simulate the measurements performed on 1000 channels and 3 links, multiplexors, transmitters, and receivers. Random numbers are generated for the measurements for the Red, Amber, and Green regions. Approximately 10% of the measurements are in the Amber region and 5% in the Red region. The SIG continually writes to three 9600 baud interfaces for the VSQC, DSQC and BWBSA. Each channel and link is simulated by a measurement report that is written to the interface. A VSQC measurement report consists of the six parameters given in Table 1-1 plus the channel number, trunk name, and monitor point. A BWBSA measurement report consists of the thirteen parameters given in Table 1-4, plus the link number and monitor point. In addition, Multiplexor, Transmitter, and Receiver Alarms are generated.

The SIG also responds to commands from the VSQC, DSQC or BSBSA to perform a measurement on a specific channel or link. Equipments which are in the Red region continue to generate Red measurement parameters for a specified number of successive measurements in order to simulate hard equipment failures and repair time.

1.1.10 Module Interconnection

The human interface to the MSCDM is via the OCRI terminal. The OCRI node is normally ATTACHED to the DBMS which runs the User Language. The DBMS responds to the ORCI node and any other ESM

terminal in the other loops. Interloop communication is done via the SSCI node. The SIG generates measurement reports to the VSQC, DSQC, and BWBSA. The PDP 11/40 in loop 2 generates switch saturation reports to the SDCA. The DBMS via Mode 3 (Module Update) of the User Language sends commands to the VSQC, DSQC, BWBSA, and SDCA. The DBMS via Modes 1 and 5 (CRT-to-CRT, Report) sends messages to other loops via the SSCI. The VSQC, DSQC, and BWBSA send Event Reports and alarms to the FIAC. The FIAC sends Event Reports, Alarms, and Fault Reports to the DBMS Status File and the OCRI. The SDCA sends Switch Saturation Reports to the DBMS Status File and the OCRI. All nodes send Nodal Error Reports (e.g. Queue Overflow) to the OCRI. The SDCA, functioning as a remote FIAC, sends and receives Event Reports to FIAC.

1.2 Alternatives and Cost Benefits

Prior to the start of the MSCDM Phase II implementation effort, a decision was made to utilize the LSI-11 microprocessor as the basic system control module. The modules are connected together by means of a fail-soft loop or ring communications network. This decision was made by the government based upon the results of the MSCDM Phase I study effort. The alternative analysis, cost benefits, and description of the recommended family of system control modules are given in the MSCDM Phase I Final Report (9). A decision was made early in the project to utilize the newer LSI-11/2 microcomputer module rather than the older LSI-11 module

for all nodes except the DBMS-PDU. The PDU is a packaged PDP11V03 containing the older LSI-11 module. The LSI-11/2 is half the size of the LSI-11. The LSI-11/2 with 64K Bytes of memory takes the same backplane space as the LSI-11. As a result the LSI-11/2 costs less and consumes less power. The backplanes used for MSCDM can accomodate both the LSI-11 and LSI-11/2 processor. The backplane used contains eight double height module slots. An MSCDM node with the LSI-11/2 uses six of these slots thus there are two spare slots per node.

The Loop Interface Unit (LIU) - LSI-11 Interface Card is the most significant development item in the project. A decision was made to provide a Direct Memory Access (DMA) type of interface rather than a simplier programmed I/O interface. The DMA interface is the fastest method of transferring data between the LSI-11 memory and the I/O buffers on the LIU. The DMA interface increases the throughput of the node since the processor spends less time handling I/O from the loop. The DMA interface costs slightly more than a comparable programmed I/O interface, and it is contained on a general purpose wire-wrap board that uses two backplane slots. The LIU-LSI-11 Interface Card is connected to the LIU via backplane wires for all nodes except the DBMS node which is connected via a 10 foot interface cable.

The OCRI terminal used for the MSCDM is a hard-copy keyboard printer (LA36 DEC writer). This was chosen rather than a CRT terminal since the ESM system currently has no hard copy terminals connected directly to the loops. The ESM CRT terminals can be ATTACHED to the DBMS and used as OCRI terminals. Also, a CRT terminal (VT52) can be connected to the OCRI node by modification of the Serial Interface Card (DLV11) for the 9600 baud CRT rather than the 300 baud DEC writer.

The Loop 4-Loop 5 interface is a 9600 baud asynchronous serial interface. This is different than the other interloop interfaces which use a special Gateway Interface Board that operates at 0.5 Megabaud. Experience with ESM using many interloop transfers (e.g., File Transfers) indicates that the Gateway Interface Card reliability is less than desirable. It is anticipated that the asynchronous interface between Loop 4 and 5 will provide more reliable interloop communication. The asynchronous interface also has cost benefits since the hardware and software are off-the-shelf.

2. EXPERIMENTAL TEST PLAN

2.1 System Control Experiments

2.1.1 DCS Hierarchy Network Configurations

The DCS System Control Hierarchy is shown in Figure 2-1. MSCDM is primarily concerned with defining modules for the lower three levels (Sector, Nodal, Station). The goal is to define a set of modules that can be applied to the lowest level, and enhanced with additional modules to be applied to the higher levels. The ESM Multiloop Network can be used to simulate DCS Hierarchy Network Configurations. The various loops or host processors can be used to simulate sites at the different levels. Where hardware/software simularities exist between the ESM and operational systems, actual operational software can be run on the host processors. For example, the ATEC program is using PDP 11/70 and LSI-11 processors. Subsets of the operational software can be modified to run on the ESM hardware. The heterogeneous nature of the ESM provides a large amount of flexibility and capability for testing and simulating operational software for the various DCS levels. The gateway nodes in ESM provide protocol, data rate, code, and security isolation between the various ESM loops. Experiments can be done where processors of different levels communicate with each other on a periodic basis; when a remote processor fails to respond the processor initiating the Are You There? message can take over the functions of the remote processor.

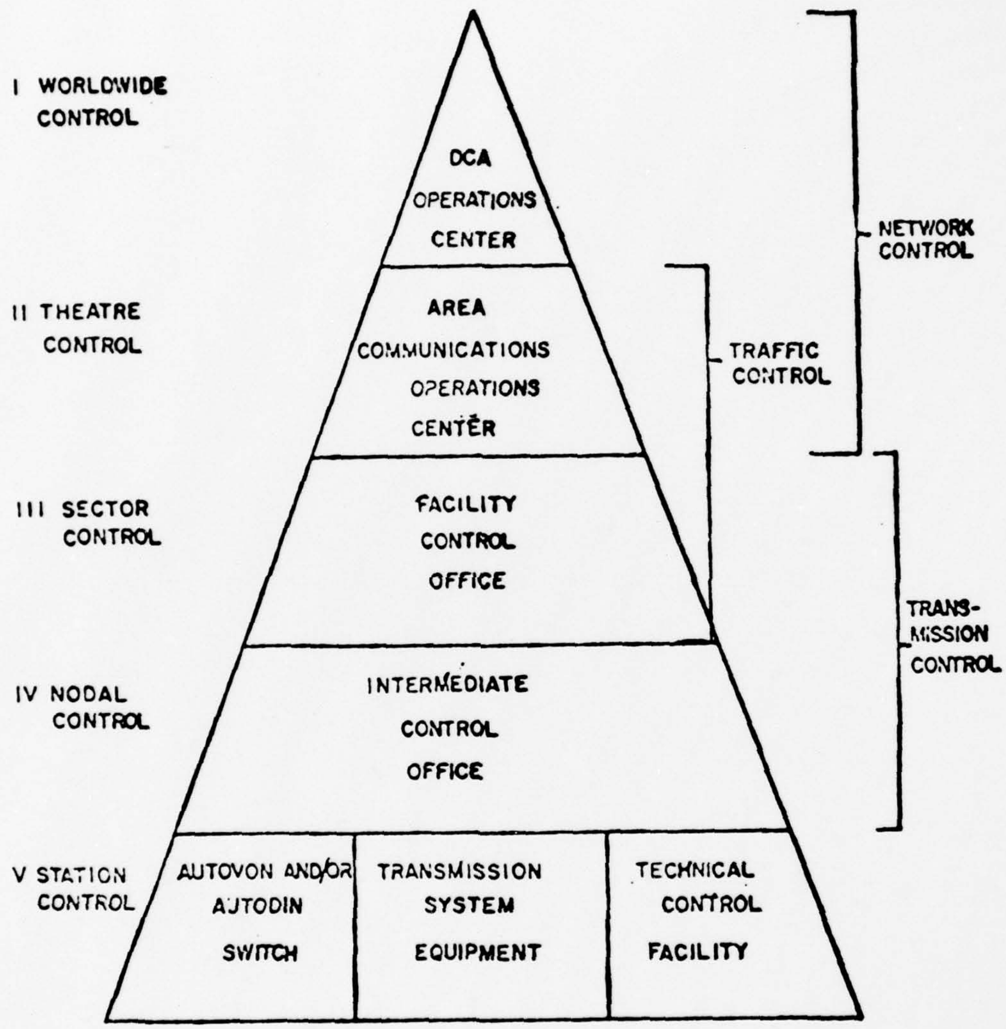


Figure 2-1. DCS SYSCON Hierarchy

Failures can be simulated and the resulting reporting sequence can be studied as reports ripple up through the System Control levels using ESM host processors and their peripherals as the different level hosts. The statistics of traffic and delay time during the reporting sequence can be measured and studied. The reports can be displayed on either loop connected or host processor connected peripherals and simulated operational direction messages can be generated and rippled down through the System Control levels. The controller actions required can be investigated. Alternate procedures requiring human decision and initiation can be compared.

System Control Center interaction experiments can be performed. The interaction involved in isolating faults and removing equipment from service between two centers can be examined. This would involve the Fault Isolation and Analysis Coordination (FIAC) module of MSCDM Loops and a similar program running on a host processor. Various fault isolation algorithms can be studied.

The tasks associated with this area include the identification of similarities between the ESM and operational systems. This would be a research-oriented task involved with studying existing software. The software would then be modified to run on the ESM. Remote backup processor experiments would be designed and implemented in ESM software. Reporting sequences would be investigated and implemented in ESM software. The tasks associated with DCS Hierarchy Network Configurations involve research into existing systems and

software implementation on ESM. The cost associated with this area can be given in terms of man-months for research oriented personnel for the investigative tasks and programmers for the implementation tasks.

The tasks, cost given as man-month estimates, and type of effort for DCS Hierarch Network Configurations are given in Table 2-1.

Table 2-1 DCS Hierarchy Network Configuration Tasks

Task	Man Months	Effort
Identify Simularities between ESM and Operational Systems	5	Research
Modify Operational Software for ESM	4	Software
Remote Backup Processor Design	3	System Design
Remote Backup Processor Implementation	3	Software
Reporting Sequence Investigation	3	Research
Reporting Sequence Implementation	3	Software
Fault Isolation Algorithm Identification	6	Research
Fault Isolation Algorithm Implementation	5	Software

2.1.2 Distributed Data Base

The ESM currently has a distributed data base consisting of circuits and trunks on the PDP 11/40 host processors using the TOTAL Data Base Management System. Experimentation can be performed in which the ESM is configured as the various levels of a System Control hierarchy with representative data bases at each level. System Control data base partitioning studies can then be performed to examine the tradeoffs between secondary storage

requirements and access times to the distributed data base as a function of network traffic. Data Base Management Systems other than TOTAL can be used and compared. The use of a non-data base management processor (e.g., B776) as a back-up for the distributed data can be investigated.

The tasks associated with the Distributed Data Base area include data base identification of existing DCS systems. A data base partitioning study would be performed resulting in the design and implementation of a distributed data base similar to that of the existing DCS systems. The use of a non-data base management processor as a back-up would be designed and implemented using ESM software.

The tasks involved with Distributed Data Base are given in Table 2-2.

Table 2-2 Distributed Data Base Tasks

Task	Man Months	Effort
Data Base Identification for Existing DCS Systems	6	Research
Data Base Partitioning Study	3	Research
Data Base Partitioning Design	3	Software Design
Data Base Partioning Implementation	4	Software
Back-up Non-DB Proc. Design	4	Software Design
Back-up Non-DB Proc. Implementation	3	Software

2.1.3 ATEC Software Tests

The software being developed for the ATEC program can be tested and evaluated on the ESM Multiloop Network. Since the ATEC System will utilize PDP 11/70 and LSI-11 hardware it is anticipated that the software developed would run on certain ESM processors with little modification. Trending, alarm thresholding, and fault isolation algorithms can be run on the ESM processors; processing delay times and partitioning methods can be studied. Various algorithms can be distributed on a set of microcomputers and/or minicomputers; the degree of coupling can be studied.

The tasks associated with ATEC Software Tests would include identifying the ATEC software to be tested, modifying the software for ESM, and then evaluating and testing the software along with the development of any support software that may be necessary (e.g., special simulators, timing software). The tasks are described in Table 2-3.

Table 2-3 ATEC Software Test Tasks

Task	Man-Months	Effort
Identification of ATEC Software to be tested	6	Research
Software Modification	5	Software
Support Software Development	3	Software
Testing and Evaluation	2	Software

2.1.4 Interoperability

Interoperability between various systems (e.g., DCS/TRI-TAC)/NATO) can be studied. The heterogeneous nature of the ESM makes it ideal for this application. Various networks can be interfaced to the nodal microprocessors. Protocols can be programmed into the nodes; hardware interface cards of various types are available. Current interfaces include Synchronous, Asynchronous, AUTODIN II, SDLC, TCCF, and IEEE 488. Protocol interfacing between the various systems can be examined. Different System Control policies in the various networks can be examined and integrated.

Interoperability tasks include identification of the characteristics of systems to be studied, special software development on both the protocol level and the I/O handler level, and possible hardware interface card development. The tasks are described in Table 2-4.

Table 2-4 Interoperability Tasks

Task	Man-Months	Effort
Identification of characterisitics of systems to be studied	5	Research
Protocol level software development (per interface)	2	Software
I/O Handler software development (per interface)	2	Software
Interface card development (per interface)	3	Hardware

Interface card material cost is estimated at $200 per interface. Interface card assembly labor is estimated at two man-days per interface.

2.1.5 CRU

The Channel Reconfiguration Unit (CRU) can be studied on the ESM. Channels may be simulated by either the gateway-to-gateway links or the links between nodes on a loop. Link failures can be simulated, and automatic reconfiguration algorithms that utilize the multiloop alternate routing capability can be performed. Routing algorithms can be studied. Processor stand-by experiments can be performed where a back-up processor will perform the tasks of a failed processor. Failure reporting and back-up processor start-up procedures can be examined.

The application of the CRU problem to ESM would be investigated in order to determine reconfiguration and processor stand-by algorithms that could be implemented for ESM. The CRU tasks are described below in Table 2-5.

Table 2-5 CRU Tasks

Task	Man-Months	Effort
Application of CRU to ESM Investigation	5	Research
Reconfiguration Algorithm Implementation	3	Software
Processor Stand-By Implementation	3	Software

2.1.6 SENET

The Slotted Envelope Network (SENET) Concept (1) developed at DCA is involved with the integration of voice and data switching. An integrated voice/data system is characterized by two classes of traffic (2). Class I traffic is characterized by long messages requiring continuous real-time delivery such as voice, facsimile, or low-speed video. The call is either accepted or blocked; once accepted, it is maintained as a virtual circuit for the duration of the call. Class II traffic consists of either short, discrete, interactive data messages, or longer store-and-forward type data messages. This type of traffic is accepted for transmission and may experience queueing delay as it travels through the network (3).

The ESM, with its currently programmed Newhall loop protocol, is best suited for Class II traffic. The Newhall protocol utilizes a special control packet called a Write Token (WT) which continually orbits the loop. When the WT is detected, a node may write one packet (at most 256 bytes) onto the loop followed by the WT. The current ESM may be best described as a packet switching network.

Since the nodal microprocessors are programmable, other types of protocols could be programmed for a hybrid approach in which both circuit switched and packet switched traffic share the loop. A special Resource Allocator/Scheduler node can be used to set up

virtual network paths between any two nodes on the loop so that the long Class I conversations can take place. Depending on the location of the nodes that wish to communicate, multiple conversations can concurrently take place on the loop.

Another approach would be to use separate loops for Class I and Class II traffic. The Jafari loop architecture (4) may be ideal for this application. This architecture is given in Figure 2-2. The inner control loop is similar to the ESM loops. The outer data loop is a segmented switched loop. The inner loop can be used for Class II traffic and to request circuits for Class I traffic. The loop controller node schedules Class I traffic conversations between nodes on the data loop. The various switches are set so that a circuit connects the nodes having the conversation. The ESM would have to be enhanced to provide the outer data loop.

The tasks for SENET are described below in Table 2-6.

Table 2-6 SENET Tasks

Task	Man-Months	Effort
Loop Protocols Investigation for Integrated Voice/Data	5	Research
Resource Allocator/Scheduler Implementation	4	Software
Jafari Loop System Design	4	System Design
Jafari Loop Hardware Implementation	6	Hardware
Jafari Loop Software Implementation	5	Software

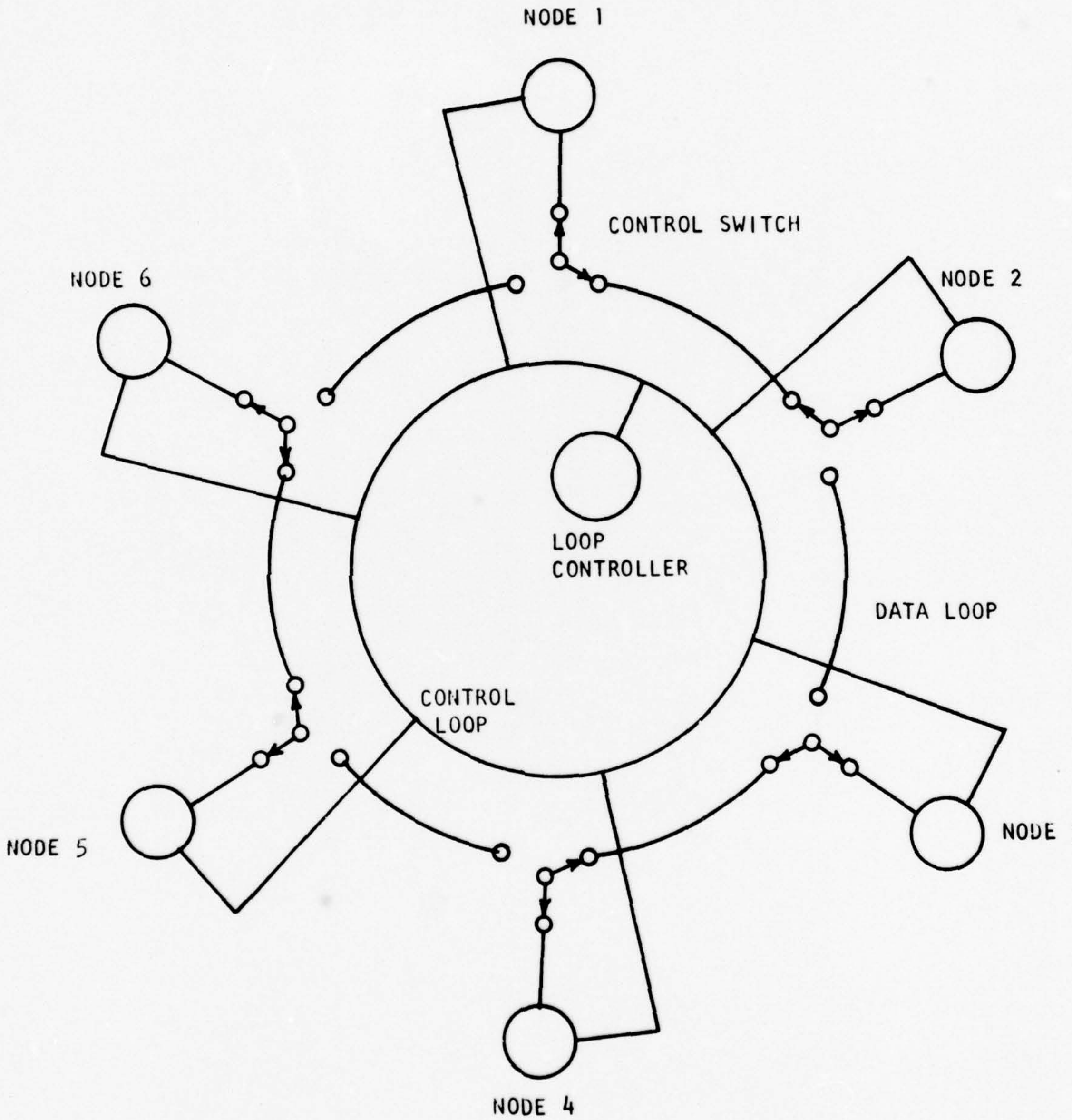


Figure 2-2. Jafari Loop Architecture

The material cost for the Jafari Loop interface is estimated at $300 per node. The assembly labor for the Jafari loop interface is estimated at two man-days per node.

2.1.7 Satellite Control

The ESM can be used to study the interface between the Defense Satellite Communications System (DSCS) System Control and DCS System Control. A major upgrade of DSCS System Control is planned using automation to improve status monitoring, reporting, and commanding (5). This improved DSCS System Control program is called RTACS (Real-Time Adaptive Control System) (6). RTACS supports the DSCS as System Control supports the DCS. RTACS is a distributed hierarchical system consisting of three conceptual elements: 1) Operational Control Element (OCE); 2) Network Control Element (NCE) and 3) Terminal Control Element (TCE). These elements interface with the levels of the DCS System Control hierarchy. For example, the OCE interfaces with the DCS DCAOC.

The ESM can be used to simulate the interactions between the RTACS elements. Various nodes can perform the functions of the OCE, NCE, and TCE. The interactions between RTACS and the DCS System Control Elements can be studied. The distributed RTACS software can be tested on the ESM. The ESM can also be used to simulate a Satellite/Terrestrial Network with a Network Control Center (NCC) (7). An ESM processor can perform the NCC function, and the various gateway or loop links can simulate the satellite or terrestrial communication links.

The tasks associated with Satellite Control are described in Table 2-7.

Table 2-7 Satellite Control Tasks

Task	Man-Months	Effort
RTACS Element Interaction Investigation	4	Research
RTACS Element Interaction Simulation Implementation	4	Software
Distributed RTACS Software Testing on ESM	4	Software
NCC Implementation	4	Software

2.2 Simulation Facility Enhancement

The flexible structure of the ESM Multiloop Network provides the modeler with the capability to perform many different types of experiments. The ESM's simulation capability is based on the characteristic that nodal microprocessors and host processors are programmable. Thus even very simple experimental simulations may required a significant number of programs to be written and debugged on the distributed system. The enhancement of the ESM to expand the modeler's capability to write application programs will improve the utilization of the system.

2.2.1 Distributed Operating System

The ESM nodal microprocessors currently run a Distributed Master Control Program (DMCP) which allows data to be passed around the network so that heterogeneous external devices can communicate with each other. The BDS and LSI-11 microprocessors of loops 4

and 5 have sufficient processor and memory capability to be used as general purpose microcomputers. They are programmable in higher level languages; i.e., ALGOL for the BDS and FORTRAN IV for the LSI-11. Since loop connected terminals can be ATTACHED to any node, I/O for the general purpose microcomputer could be done via the loop.

The general purpose microcomputer capability would require the enhancement of the DMCP to function as a general purpose operating system. The Stack Machine Operating System on the B776 could be used on the BDS microcomputers, and the RT-11 Operating System on the PDP11V03 could be used on the LSI-11 microcomputers. These operating systems require a disk. Thus for this application, the operating systemsmust be distributed so that disk I/O would be done via the loop. This would require the development of a file-request processor and file-server processor so that each remote loop 4 and 5 microprocessor can do disk I/O to a host processor with disk. In addition, an On-Line Loading capability would have to be provided so that different application programs can be run dynamically on loop 4 and 5 microcomputers. These programs would be stored on a host processor's disk and loaded to the remote microcomputer via the loop when a RUN command was entered on the terminal ATTACHED to the remote node.

The software tasks to implement a distributed operating system would include the enhancement of the DMCP for use of a remote processor with a general purpose operating system such that disk I/O is done via the loop. Also included are tasks to develop the

File-Server program to handle disk I/O from remote processors, and an On-Line loader program. The tasks are given in Table 2-8. The man-month estimates given are for an implementation on loop 4 or loop 5. Implementation on both loops would require duplicate coding and debugging since loop 4 is programmed in ALGOL and loop 5 is programmed in FORTRAN.

Table 2-8 Distributed Operating System Tasks

Task	Man-Months	Effort
DMCP Enhancement for General Purpose OS	4	Software
File-Server Development	4	Software
On-Line Loader Development	3	Software

2.2.2 User Interface Enhancement

The User Interface to the ESM should be enhanced to provide information to the inexperienced user and additional capability to the experienced user. A resource allocator program could be developed such that upon login system users will be informed of available simulation facility resources. Instructions on using the resources and the capability to ATTACH to the resources would be provided. The displays to the user would be consistent throughout the system. The displays would be easy to use and could utilize the forms mode capability of the Burroughs terminals; a cursor can be moved in a menu-selection type of display to select resources. File listings can be scrolled on the terminals.

An enhanced file transfer utility can be developed so that files can be transferred between all ESM host processors. A minimal utility currently exists (LPFT) for transferring files between the B776 and the PDP 11/40 processors. Other enhancements would include improved loading and diagnostic software, and a Supervisory Printer Output (SPO) node which would log system errors and allow the operator to reconfigure the system to account for hardware failures.

Man-month estimates for User Interface Enhancement software tasks are given in Table 2-9.

Table 2-9 User Interface Enhancement Tasks

Task	Man-Months	Effort
Resource Allocator Development	4	Software
File Transfer Utility Development	2	Software
Improved Loading Utility Development	1	Software
Improved Diagnostic Software	3	Software
SPO Program Development	4	Software

2.2.3 Equipment Interfacing

Since the heterogeneous nature of the ESM allows terminals to ATTACH to any processor and processors to communicate with each other, it would be advantageous to the modeler to have many different resources interfaced to the ESM. The attachment of host

processors to the ESM is relatively straight-forward. The operating system of the host processor is not modified· instead the nodal microprocessor is programmed to emulate a terminal connected to the host processor. In this manner the modeler can do software development on many different machines and operating systems. The loop connected terminals act as if they were local terminals connected to various loop connected host processors. In addition, using the loop broadcast capability, a terminal can input commands to two or more loop connected processors at the same time. This feature would be useful for developing distributed system software where machines run copies of the sam esoftware except for addresses.

Another useful piece of equipment that could be interface to ESM would be a node controlled line printer. The line printer could be used by all host processors to obtain source file listings, and as a monitor for displaying system error messages.

The software cost estimate for interfacing a processor or line printer to ESM is two man-months. Necessary hardware would include an interface card and cable estimated at $200. In addition, the interfaced equipment would have to be supplied or made available to ESM.

2.2.4 Scenario Generation

It would be useful to the modeler to have a scenario generation capability for experiments. A general simulation model could be developed which allows experiments to be defined with various parameters and provide restart points for extended simulations. An events simulator could be developed to provide parameterized scenarios which can be stored on disk or tape and used to provide simulated inputs to the system. The System Control Mode 3 of the User Language on Host Processor B could be enhanced so that LID/FAD conversion table values for all nodes corresponding the various experiments can be loaded on command. A fault-box simulator panel could be built such that faults may be introduced to the system via a centralized switching panel.

Experiments comparing centralized vs. distributed System Control operation could be performed. Comparisons could be made between a program running on a single minicomputer and distributed on more than one minicomputer. The delay times and overheads could be investigated.

Table 2-10 describes the tasks associated with Scenario Generation.

Table 2-10 Scenario Generation Tasks

Task	Man-Months	Effort
General Simulation Model Development	6	Software
Events Simulator Development	4	Software

2.2.5 PDP 11/70 Application Programs

The ESMD project demonstrated the feasibility of connecting loop 4 to a PDP 11/70 processor by programming the BDS microprocessor to emulate a VT52 DECScope. The PDP 11/70 could be enhanced with additional software and used as a System Control host processor in the ESM. The interface displays could be enhanced so that the loop connected terminal appears more like the local DECScope and becomes easier for the operator to enter data. A demonstration was performed for the ESMD Acceptance Test in which the PDP 11/70 monitors a CRT-B776 conversation using the non-destructive read capability of loop 4 and 5 nodes in order to function as a security monitor which removes the CRT from the network when a bad password is detected. This security monitor function can be enhanced and studied. Another enhancement would be to use the PDP 11/70 as a reliability monitor for ESM hardware. Diagnostics could be performed and On-Line and Off-Line configurations could be defined.

Man-month software estimates for PDP 11/70 tasks are given in Table 2-11

Table 2-11 PDP 11/70 Application Programs

Task	Man-Months	Effort
System Control Host Processor Utilization	2	Software
Interface Display Enhancement	2	Software
Security Monitor	2	Software
Reliability Monitor	3	Software

2.3 Distributed System Control Investigation Areas

The ESM could be used as a Research and Development tool to study various characteristics of a distributed processing system. In particular the problems involved with a distributed System Control architecture can be investigated.

2.3.1 Distributed Operating System for Multiprocessing

The effects of a multiprocessor environment on the System Control function can be investigated on loops 4 and 5. Especially important would be experiments related to the impact of a multiprocessor configuration on processing speed and functional module decomposition. Experiments could be designed for measuring the processing time needed to support interprocessor interactions and the full extent of interprocessor communications requirements as a function of module decomposition.

Distributed Operating Systems could be mapped on the ESM hardware and investigated. The amount of overhead involved with inter-processor communications as a function of the degree of coupling can be studied. The advantages and disadvantages of a distributed multi-microprocessor architecture versus a single minicomputer architecture can be studied by comparing the execution of software running on one minicomputer with a distributed version of the software running on many microcomputers with a distributed operating system.

The tasks associated with a Distributed Operating System for Multiprocessing are given in Table 2-12.

Table 2-12 Distributed Operating System for Multiprocessing Tasks

Task	Man-Months	Effort
Distributed Operating System Design	7	Research
Distributed Operating System Implementation on ESM	7	Software
Measurement and Evaluation of Implemented System	5	Research

2.3.2 Network Architectures

The ESM can be used to study network architectures. Experimentation can be performed with different network protocols suitable for the System Control environment. System Control architectures can be simulated on the Multiloop Network in order to check for inadequacies in network protocols at each layer of the network.

Experiments comparing centralized vs. distributed System Control operation could be performed. Comparisons could be made between a program running on a single minicomputer and distributed on more than one minicomputer. The delay times and overheads could be investigated.

The connection of the ESM to additional DCAHSF host systems can be used for larger scale System Control network architecture studies. This connection will provide additional processing and storage resources for examining larger data bases, more System Control hierarchical levels, and additional programming languages, operating systems and utilities. The addition of a loop node connected line printer would provide hard copy printout capability to all nodes in the system. Measurement equipment could be connected to loop 5 using the IEEE Standard 488-1975 Digital Interface for Programmable Instrumentation (via IBV11-A interface - Node 27).

Table 2-13 describes the tasks associated with the study of Network Architectures.

Table 2-13 Network Architecture Tasks

Task	Man-Months	Effort
Identification of Network Architectures	3	Research
Identification of Network Protocols	5	Research
Implementation of Protocols on ESM	5	Software
Evaluation and Conclusions	3	Research

2.3.3 Throughput Analyses

The ESM can be used to perform network throughput and response time analyses. Network overload simulations could be performed by generating excessive traffic by processors. Delay times and queue sizes at various loop operating speeds could be displayed and studied. The effect of emergency messages attempting to penetrate an overloaded network could be examined. Mathematical models could be developed and verified by the simulation results. Trace messages could be generated and displayed that monitor queue sizes, arrival and departure times, and nodes traversed as they are sent from a source node to a sink node.

Table 2-14 describes the tasks associated with Throughput Analyses.

Table 2-14 Throughput Analyses Tasks

Task	Man-Months	Effort
Mathematical Model Development	4	Research
Network Traffic Simulator Software Development	3	Software
Trace Message Detection Software Development	3	Software
Evaluation and Conlusions	3	Research

2.3.4 Security

Experiments could be performed to study the effects of distributing LID and node controller functions as described in Section 3 (Security) of the ESMD Final Report (8). Experiments could be performed in the areas of N'th party authorization problems in a networking environment, distributed logon procedures and security monitoring/auditing procedures. The estimated cost of security related tasks is 18 man-months.

APPENDIX A

GLOSSARY OF ACRONYMS

The interdisciplinary nature of the present study is emphasized by the large number of different acronyms, from diverse sources, that appear in the discussion. The following is a partial list of some of the relevant acronyms that have been identified. It also serves as a glossary.

ACAS	AUTOVON Centralized Alarm System
ACOC	Area Communications Operations Center
ADM	Adaptive Delta Modulation
ADO	Burroughs Advanced Development Organization
ASC	Automatic Swtiching Center (AUTODIN)
ASCII	American Standard Code for Information Interchange
ASCC	AUTODIN Station Control Console
ASSC	AUTODIN Station Supervisory Console
ASU	Alarm Scanner Unit
ATEC	Automated Tech Control
AVIE	AUTOVON Information and Evaluation Network
BARS	Buffered Automatic Reporting System
BBSA	Baseband Signal Analysis

BDLC	Burroughs Data Link Control
BLIUI	Bus Loop Interface Unit Interface
BWBSA	Combined functions of BBSA and WBSA
CCI	Command and Control Interpreter
CPU	Central Processor Unit
CRT	Cathode Ray Tube
DCA	Defense Communications Agency
DCAOC	Defense Communications Agency Operations Center
DCEC	Defense Communications Engineering Center
DCS	Defense Communications System
DBMS	Data Base Management Service
DDMS	Digital Distortion Monitoring Subsystem
DMA	Direct Memory Access
DSQC	Digital Service Quality Control
ESM	Exploratory System Control Model
ESMD	Exploratory System Control Model Development
FDM	Feasibility Development Model
FIAC	Fault Isolation and Analysis Coordination
IO	Input/Output
LA-36	DEC Hard Copy Terminal
LIU	Loop Interface Unit
MSCDM	Modular System Control Development Model
OCRI	Operator Control and Report Interface
PDU	Program Development Unit
PROM	Programmable Read Only Memory

RAM	Random Access Memory
SDCA	Switch Data Collection/Analysis
VSQC	Voice Service Quality Control
WBSA	Wideband Signal Analysis
WT	Write Token

References

(1) Coviello, G. and Vena, P., "Integration of Circuit/Packet Switching by a SENET (Slotted Envelope Network) Concept", NTC, New Orleans, LA, Dec. 1975.

(2) Ross, M. J., "System Engineering of Integrated Voice and Data Networks", ICC '78, pp. 20.5.1 - 20.5.4.

(3) Ross, M. J.; Tabbot, A. C.; and Waite, J. A., "Design Approaches and Performance Criteria for Integrated Voice/Data Switching", Proc. of the IEEE, Vol, 65, No. 9, Sept. 1977, pp. 1283-1295.

(4) Jafari, H., "A New Loop Structure for Distributed Microcomputing Systems", Ph.D. Thesis, Oregon State Univ., Dec. 1977.

(5) Sherwin, R. P., "Management and Control of Military Satellite Communications Systems", ICC '78, pp. 3.1.3.1 - 3.1.3.5.

(6) Alvarez, R.; Bustamante, H. A.; Spilker, J. J.; and Witherspoon, J. T.; "Definition of Real-Time Adaptive Control (RTAC) of the Defense Satellite Communications System (DSCS)", Report STI TR-1215 for Contract No. DCA100-75-C-0062, Dec. 1975.

(7) Ricci, F. J., "Control of Satellite-Packet Switched Telecommunications Networks", ICC '78, pp. 23.1.1 - 23.1.3.

(8) Burroughs Corp., "ESMD Final Report", Doc. 64297, Paoli, PA, Jan. 1978.

(9) Burroughs Corp., "Phase I Final Report for the MSCDM", Doc. 64280, Paoli, PA, Sept. 1977.

References

(1) Coviello, G. and Vena, P., "Integration of Circuit/Packet Switching by a SENET (Slotted Envelope Network) Concept", NTC, New Orleans, LA, Dec. 1975.

(2) Ross, M. J., "System Engineering of Integrated Voice and Data Networks", ICC '78, pp. 20.5.1 - 20.5.4.

(3) Ross, M. J.; Tabbot, A. C.; and Waite, J. A., "Design Approaches and Performance Criteria for Integrated Voice/Data Switching", Proc. of the IEEE, Vol, 65, No. 9, Sept. 1977, pp. 1283-1295.

(4) Jafari, H., "A New Loop Structure for Distributed Micro-computing Systems", Ph.D. Thesis, Oregon State Univ., Dec. 1977.

(5) Sherwin, R. P., "Management and Control of Military Satellite Communications Systems", ICC '78, pp. 3.1.3.1 - 3.1.3.5.

(6) Alvarez, R.; Bustamante, H. A.; Spilker, J. J.; and Witherspoon, J. T.; "Definition of Real-Time Adaptive Control (RTAC) of the Defense Satellite Communications System (DSCS)", Report STI TR-1215 for Contract No. DCA100-75-C-0062, Dec. 1975.

(7) Ricci, F. J., "Control of Satellite-Packet Switched Tele-communications Networks", ICC '78, pp. 23.1.1 - 23.1.3.

(8) Burroughs Corp., "ESMD Final Report", Doc. 64297, Paoli, PA, Jan. 1978.

(9) Burroughs Corp., "Phase I Final Report for the MSCDM", Doc. 64280, Paoli, PA, Sept. 1977.